**WATER SUPPLY**
**OPPORTUNITIES AND CONSTRAINTS**
**FOR THERMAL POWERPLANTS**
(January 25, 2001)

## INTRODUCTION

This paper describes water use requirements, water supply opportunities, and water permitting constraints that may affect the viability of proposals for constructing and operating new thermal powerplants in California. The information should provide the foundation for addressing questions posed by the Siting Committee regarding powerplant water use and supply which will be discussed at a workshop at the California Energy Commission in Sacramento on February 8, 2001. The purpose of the workshop is to develop the information needed for the Committee to identify appropriate actions, if any, needed to avoid constraints to the licensing of future powerplants due to the lack of adequate water supply options.

## STATE'S WATER SUPPLY

Power generation in California consumes about 235,000 acre-feet of water per year. This is approximately the same amount of water used by 470,000 households, or about 0.3 percent of the total statewide consumption of 78 million-acre feet. Although the relative amount of consumption is low, the Department of Water Resources predicts that water shortfalls will increase and may total 2.4 million-acre feet annually by the year 2020. In addition, water use for powerplant cooling reduces the amount of water available for other uses, such as industrial, commercial, agriculture and residential development. As California's population and water demand continue to grow, there will be increasing pressure for heavy industry, including powerplants, to reduce water use, and powerplant developers are likely to find themselves competing with other users for diminishing supplies.

In 1975, the State Water Resources Control Board Water Quality adopted its *Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Powerplant Cooling*, in part, to address the issue of diminishing availability of water. (Policy, or Resolution 75-58) The Board stated that the purpose of the Policy is to guide planning of generating facilities to protect beneficial uses of the State's water resources and to keep consumptive use of fresh water for powerplant cooling to a level that is "minimally necessary for the welfare of the citizens of the state." The Policy expresses a preference for use of 1) wastewater being discharged to the ocean, 2) ocean water, 3) brackish water from natural sources or irrigation return flow, 4) inland wastewaters of low TDS (total dissolved solids), and 5) other inland waters. Although the Policy does not mention dry cooling, some intervenors in recent siting cases have argued that the policy establishes a preference for dry cooling, followed by the five sources listed above.

The Energy Commission has never explicitly addressed the applicability of the Policy to siting cases. And, while it is true that dry cooling and use of the alternative

water supplies identified in the Policy may avoid environmental impacts associated with the use of fresh inland water for cooling, the Commission has never found that the Policy mandates either dry cooling or any of the alternatives in a given case. Rather, Commission staff has conducted a comparative analysis of dry cooling and wet-dry cooling as well as an evaluation of the availability of alternative water supplies in its Final Staff Assessment.

In addition, powerplant developers may face project-specific constraints related to availability, pricing, and environmental concerns. The ability and willingness of local water districts to provide water to powerplant developers can vary dramatically from district to district, as can environmental impacts associated with the use of various water sources. There appears to be agreement that water prices throughout the state will rise, in some cases dramatically, during the next two decades. Finally, powerplants using water for cooling may also face environmental constraints in planning for the disposal of cooling tower wastewater.

In 1997, the Energy Commission and the State Water Quality Control Board entered into a Memorandum of Understanding in order to coordinate the review of applications for projects for which a regional water quality control board or the State Board have responsibilities. Although new appropriations of surface water for powerplant cooling are unlikely, the water boards frequently have responsibility for issuing Waste Discharge Requirements or approving waste discharges subject to the National Pollutant Discharge Elimination System permit system. In addition, changes in the use of reclaimed water, which is favored for use in powerplant cooling under Resolution 75-58, may need to be approved by the State Board.

## WATER USE REQUIREMENTS

*Wet-Cooled Combined-Cycle Facilities.* A conventional 500 MW thermal combined cycle gas-fired powerplant consumes between 2,000 to 4,000 acre-feet of water per year (equivalent to the amount used by 4,000 to 8,000 homes). The majority of this water, 80 to 90 percent, is used in a closed loop wet cooling system. Cooling towers reject heat from a powerplant's steam cycle by evaporating water in the cooling towers in order to condense the steam exiting the steam turbine and to maintain the lowest possible condenser vacuum. The amount of water used can be reduced if the facility cycles water through the cooling towers as much as possible. Hundreds of acre-feet of water can be saved by a facility cycling water 15 to 20 times through the cooling towers instead of just five. This approach reduces water supply costs, but may also create wastewater quality problems that must be addressed through additional treatment. Most combined-cycle plants being proposed in California incorporate a wet cooling system. They are cheaper to construct and do not experience the reduction in efficiencies inherent in dry-cooled plants that are discussed below.

*Cogeneration Facilities.* In comparison, cogeneration facilities use less water for cooling than a combined cycle or steam boiler, as rejected heat is used in industrial processes, rather than used to generate steam for power production, which would require a cooling cycle. Cogeneration facilities are frequently used to provide steam

for thermally-enhanced oil recovery, food processing, and a variety of other industrial activities.

*Simple Cycle Facilities.* A simple cycle facility does not incorporate a steam cycle and hence does not require cooling towers. As a result, these facilities use significantly less water than combined cycle facilities. Typical consumption ranges from 60 to 200 acre-feet per year; uses are primarily for inlet evaporative cooling, domestic activities, and maintenance. Simple cycle facilities are much less efficient than combined cycle facilities, but can operate very effectively as peaking facilities, due to their ability to reach full power output quickly.

*Dry-Cooled and Wet/Dry-Cooled Combined-Cycle Facilities*. Powerplants can also use a dry cooling system or a wet/dry hybrid system. Dry cooling can reduce a project's water demand by up to 90 percent, although even a dry-cooled powerplant requires a small amount of water, on the order of 200 – 400 acre-feet per year, for boiler make-up and domestic uses. Dry cooling towers transfer heat convectively through heat exchangers, while wet/dry hybrid cooling towers use combinations of the two mechanisms to reject heat to the atmosphere. Dry cooling systems are two to three times more expensive than a wet cooling system. Hybrid systems fall in the range between the two, depending upon the ratio of "wet to dry" cooling in the hybrid design. Not taken into account in these relative cost estimates are a variety of factors, including the cost of water, which will likely increase over time, and the environmental compliance requirements associated with the use of water for cooling. Perhaps more important over the life of a project, use of these technologies may avoid curtailment of a project's water supply.

Dry cooling and hybrid systems have another significant economic disadvantage in that heat rejection inefficiencies inherent in dry cooling towers can reduce net generator output. These losses increase as the temperature increases, reducing output during summer peak conditions. Finally, dry cooling can create more noise than wet cooling and require larger amounts of land.

## WATER SUPPLY OPTIONS

The quantity and type of water required is the first consideration in evaluating water supply options. For plants that will use wet cooling, a variety of water sources may be available. Powerplant developers may rely on a local water district to obtain water (which can be groundwater, surface water, or a combination of the two), contract with a private entity for surface water or groundwater, or may pump groundwater themselves. Other available sources include water transfers, reclaimed wastewater and treated brackish or contaminated water.

*Surface water*: For much of the state, surface water supplies are provided by two major water projects, the Central Valley Project and the State Water Project that route water from Northern California through the Sacramento-San Joaquin River Delta to Central and Southern California. The state water project delivers, on average, 2.1 million acre-feet per year. This amount is expected to increase to 3.4 million acre-feet per year by 2020. The purveyors of water from these projects have

annual allocations that they are entitled to purchase; however, in the event of shortages, not all the allocation may be available. These reductions could have an impact on the reliability of the state's electrical system if they occur during drought (which is when they are likely to occur), as less generation from hydroelectric generation will be available. In addition, the use of surface water appears disfavored by Resolution 75-58, although the Energy Commission has licensed projects using surface water when other sources are unavailable.

*Groundwater*: Many powerplants in the state rely on groundwater pumped from their own wells on or near the site. Such an approach provides the facility with control of its water supply and is relatively inexpensive. In non-adjudicated basins (most basins in the state have not been adjudicated), there is no regulatory control over pumping of percolating groundwater other than well design requirements. Use of groundwater from a subterranean stream does require a water right permit. However, pumping of groundwater can cause localized environmental impacts, such as well interference, reductions in discharge to nearby springs and streams, lowering of water tables, and movement of saltwater and/or groundwater pollution into different parts of the aquifer.

Project developers may also contract with a local water district to supply groundwater to the project. This avoids the need to invest in infrastructure and may result in avoiding environmental scrutiny of the impacts of pumping water for the project. Groundwater is fresh inland water for purposes of Resolution 75-58 and its use is therefore disfavored, although the Energy Commission has licensed projects using groundwater when other sources are unavailable.

*Diversions of Surface Water.* A project developer could also seek new diversions of surface water. However, this would likely require that the State Water Resources Control Board issue a new appropriative water right permit for that use. Given the over-allocation of many water bodies, competition for remaining supplies, and the significant environmental concerns related to water diversions, this approach is unlikely to be used by developers.

*Water Transfers.* Another option is water transfers. A water transfer is a change in the allocation of water supplies, which may simply be between neighboring farmers or between water districts in different areas of the state. Changes in allocation can be short-term, long-term, or permanent. Transfers can be used to supply all of a powerplant's water needs or to augment water supplies when necessary. In response to recent droughts, water transfers have been used increasingly to alleviate shortfalls and are a key element of the Cal-Fed accord. In addition, state law encourages public agencies to facilitate water transfers. However, several legal challenges have been made to development projects relying on transfers as a source of water, due to the concern about the actual availability of water for the project once it is constructed. In some instances, water transfers require the approval of the State Water Resources Control Board.

*Wastewater and Treated Effluent.* Many wastewater treatment plants, responding to a state mandate to recycle, provide effluent for beneficial uses. In addition, California Water Code Section 13550 et seq. requires the use of effluent for

industrial purposes, especially for cooling if it is available under certain conditions. Resolution 75-58 encourages the use of these sources of water for powerplant cooling. Although most recycled wastewater and treated effluent is used for irrigation, it may be available for powerplant cooling, although such changes may require approval of the State Water Resources Control Board. A number of powerplants within the state already use wastewater for use in cooling towers and one combined cycle plant currently under construction will use wastewater for both cooling and steam cycle processes. Draft Department of Health Regulations require the use of tertiary treated, disinfected effluent in cooling towers. Although most wastewater facilities within the state provide only secondary treatment, the addition of the necessary filtration and chlorination to achieve tertiary treated standards is not a significant cost. One limiting factor in the use of wastewater or treated effluent is that it is often unavailable in the quantities needed to meet the cooling needs of a large plant using wet cooling only.

*Brackish or Contaminated Water*: Another alternative to the use of fresh water is to utilize surface or groundwater sources not suitable for most agricultural or urban uses because of natural or anthropogenic contamination. Resolution 75-58 encourages the use of these and other sources such as irrigation return flows. However, in many locations irrigation return flows vary greatly with the season and could not be considered a reliable, year-round water supply.

*Ocean Water.* Many existing coastal plants use ocean water in a process known as "once-through" cooling. Use of ocean water is favored by Resolution 75-58, although once through cooling may result in impingement, entertainment or thermal impacts to biological resources. Once-through cooling is used by many existing coastal projects. Repowering of these projects may result in the regional water quality control board treating the thermal discharge as a new discharge, and may require reevaluation of federal and state permit conditions. Typically, establishment of a comprehensive database on the existing biological resources potentially being impacted is required for any proposal to repower or modernize. In addition, the State Water Resources Control Board has adopted an Ocean Plan and a Thermal Plan, with which such projects must comply.

## CONCLUSION

While water consumption by power generation within the state represents only a small fraction of the total amount of water consumed within the state, powerplant water use reduces the amount available for other uses, and wet-cooled powerplants may soon be competing with other users for diminishing and expensive supplies. In addition, proposals to use groundwater, surface water, and water transfers may encounter project-specific constraints related to availability, pricing, and environmental concerns. There are alternatives to these sources, including recycled water and the use of dry cooling technologies. The Energy Commission is interested in addressing powerplant water requirements and water supply issues promptly so that water supply does not create a constraint to permitting needed plants.

For further information on this topic, please contact the California Energy Commission staff at:

Environmental Protection Office
1516 Ninth Street, MS 16
Sacramento, CA 95814
(916) 654-4162